C02029: Doctor of Philosophy
CRICOS Code: 009469A
32903 PhD Thesis: Analytics
January 2019

A Study on
Automated Handwriting Understanding

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Automated Handwriting Understanding

A thesis submitted in partial fulfilment of the requirements
for the degree of

Doctor of Philosophy
in
Analytics

by

Chandranath Adak

to

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NSW - 2007, Australia

January 2019

Abstract

Handwriting is a concatenation of graphical symbols drawn by a pen or other writing instruments, using a hand in order to represent linguistic constructs for communication and knowledge storage. These graphical marks/writing symbols have deep orthographic relation to the phonology of a spoken language. However, to a machine, handwriting is nothing but a pattern. Therefore, recognition of this pattern is performed in order to read a manuscript by a computer. Such a process of automatic character pattern recognition from an optically scanned document image is called OCR (Optical Character Recognition). Nowadays, the computer vision method is not limited to simply recognizing patterns/objects. It tries to endow the machine a human-like intelligent ability. The main goal of this research is using computer vision to bridge the gap between pattern recognition and human perception of handwriting. In this thesis, we focus on understanding the handwriting, which is beyond simply recognizing the characters by OCR. Towards this aim, we peek into the implicit information of handwriting to understand some inherent characteristics.

In this thesis, we concentrate on three aspects. First, understanding the generation of handwritten information by the writing body; second, understanding the writing strokes in regards to the quality of handwriting; third, understanding the content revealing handwritten word entities. Thus, the thesis contains three parts. Regardless of past researches on writer inspection, it is hard to find an empirical study performed on intra-variable handwriting, although such variation should be an important concern. The first part of this thesis addresses this concern. Besides, this part inspects the writer on some unconventional aspects, e.g., writing variability over struck-out texts, multiple scripts, etc. The second part makes a pioneering contribution to understanding writing stroke information in multiple facets, such as legibility, aesthetics, difficulty, and idiosyncrasy of strokes. The third part of the thesis approaches to comprehend the content of the handwritten document using computer vision, without the aid of a transcription engine or the natural language processing which, according to our knowledge, is the earliest attempt of its kind.

This research has adapted the traditional machine learning approaches as well as state-of-the-art deep learning approaches and has proposed new techniques to automate the process of handwriting understanding. The performed experiments have produced encouraging results, which ensure the applicability of the proposed research. This study has an impact on general image processing, pattern recognition, machine learning, and deep

learning domains, especially on document image processing and handwriting processing. Moreover, this research contributes to forensics for questioned document examination, biometrics for behavioral analysis through handwriting, library science/archival science for e-archiving of the manuscript, and data science. According to us, this study has pushed the frontiers of handwriting-related research.

AUTHOR'S DECLARATION

I, *Chandranath Adak* declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Software, Faculty of Engineering and Information Technology at the University of Technology Sydney, Australia, is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This document has not been submitted for qualifications at any other academic institution. This research is supported by the Australian Government Research Training Program.

SIGNATURE: Production Note: Signature removed prior to publication.

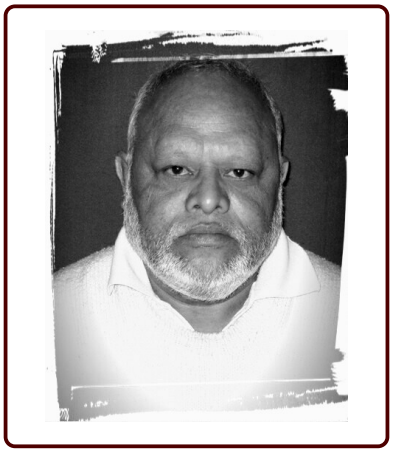
[Chandranath Adak]

DATE: 18th January, 2019

PLACE: Sydney, Australia

Dedication

To my father . . .



Late Baidyanath Adak

ACKNOWLEDGMENTS

My sincere gratitude is to my principal supervisor Prof. Michael Blumenstein, University of Technology Sydney (UTS), for his guidance and support during my Ph.D. candidature. His continuous encouragement and advice have made our research very productive. I would also like to convey my gratitude to my external co-supervisor Prof. Bidyut Baran Chaudhuri, Indian Statistical Institute (ISI), for his guidance, advice and constant motivation. For the advancement of our research, he literally acted as a critical reviewer with counter arguments and meticulous insistence on various aspects.

I would like to thank my co-supervisor Prof. Chin-Teng Lin, UTS, for his support and advice. I extend my special thanks to A/Prof. Simone Marinai, DINFO, University of Florence, Italy for his insightful advice during my visit to his lab, and IEEE Computational Intelligence Society for providing research grant for this visit.

I transferred my Ph.D. from Griffith University, Australia to UTS, following my principal supervisor Prof. Blumenstein. I heartily thank School of ICT, IIIS, and GGRS of Griffith University for supporting my initial Ph.D. research. I gratefully acknowledge all the faculty members, admin staffs, fellow researchers, GUGC student guild members of Griffith University. A special thanks to then my associate supervisor A/Prof. Jun Jo, Griffith University, for his constant support during my Griffith days.

Moreover, I express my gratitude to all the faculty members, admin staffs, fellow researchers of School of Software, CAI, and FEIT; and GRS staffs of UTS for their continuous support. I wish to thank all the faculty members and fellow researchers of CVPR Unit, Indian Statistical Institute for fruitful discussion during my ISI visits.

I also benefited from the constructive comments and suggestions made by several fellow researchers, domain experts met in conferences/academic gatherings, and also from anonymous reviewers of my papers. I thank all of them.

Heartfelt thanks to Dr. Abhijit Das (INRIA), Dr. Soumya Dutta (LANL), Tanmoy Nandi (ISI), Sumit Kr. Saha (ISI), Muhammad Saqib (UTS), Di Wu (UTS) for their help and support.

Finally, I am thankful to all my family members, especially my wife Soumi Chattopadhyay (IIITG), for constant encouragement, enthusiasm and support. I thank all those, whom I missed out from the above list.

List of Publications

Related to the Thesis :

1. C. Adak, B. B. Chaudhuri, M. Blumenstein, *An Empirical Study on Writer Identification & Verification from Intra-variable Individual Handwriting*, **IEEE Access**, vol. 7, no. 1, pp. 24738-24758, 2019.

2. C. Adak, B. B. Chaudhuri, M. Blumenstein, *A Study on Idiosyncratic Handwriting with Impact on Writer Identification*, Proc. 16th Int. Conf. on Frontiers in Handwriting Recognition (**ICFHR**), pp. 193-198, Niagara Falls, USA, 5-8 Aug., 2018.

3. C. Adak, B. B. Chaudhuri, M. Blumenstein, *Cognitive Analysis for Reading and Writing of Bengali Conjuncts*, Proc. 31st Int. Joint Conference on Neural Networks (**IJCNN**), Rio de Janeiro, Brazil, 8-13 July, 2018.

4. C. Adak, S. Marinai, B. B. Chaudhuri, M. Blumenstein, *Offline Bengali Writer Verification by PDF-CNN and Siamese Net*, Proc. 13th Int. Workshop on Document Analysis Systems (**DAS**), pp. 381-386, Austria, 24-27 Apr., 2018.

5. C. Adak, B. B. Chaudhuri, M. Blumenstein, *Legibility and Aesthetic Analysis of Handwriting*, Proc. 14th Int. Conf. on Document Analysis and Recognition (**ICDAR**), pp. 175-182, Kyoto, Japan, 9-15 Nov., 2017.

6. C. Adak, B. B. Chaudhuri, M. Blumenstein, *Impact of Struck-out Text on Writer Identification*, Proc. 30th Int. Joint Conf. on Neural Networks (**IJCNN**), pp. 1465-1471, Anchorage, Alaska, USA, 14-19 May, 2017.

7. C. Adak, B. B. Chaudhuri, M. Blumenstein, *Writer Identification by Training on One Script but Testing on Another*, Proc. 23rd Int. Conference on Pattern Recognition (**ICPR**), pp. 1148-1153, Cancun, Mexico, 4-8 Dec., 2016.

8. C. ADAK, B. B. CHAUDHURI, M. BLUMENSTEIN, *Named Entity Recognition from Unstructured Handwritten Document Images*, Proc. 12th Int. Workshop on Document Analysis Systems (**DAS**), pp.375-380, Santorini, Greece, 11-14 Apr., 2016.

OTHERS :

9. C. ADAK, B. B. CHAUDHURI, M. BLUMENSTEIN, *Offline Cursive Bengali Word Recognition using CNNs with a Recurrent Model*, Proc. 15th Int. Conf. on Frontiers in Handwriting Recognition (**ICFHR**), pp. 429-434, Shenzhen, China, 23-26 Oct., 2016.

10. C. ADAK, P. MAITRA, B. B. CHAUDHURI, M. BLUMENSTEIN, *Binarization of Old Halftone Text Documents*, Proc. **IEEE TENCON**, IEEE Conf. # 35439, pp. 1-5, Macau, China, 1-4 Nov., 2015.

11. B. B. CHAUDHURI†, C. ADAK†, *An Approach for Detecting and Cleaning of Struck-out Handwritten Text*, **Pattern Recognition**, vol. 61, pp. 282-294, January 2017. †*Joint first author*.

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